Computer Generated Translation of JP 2000-321097

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] The light source A reflecting grating board with which two or more reflecting gratings of a predetermined configuration were formed at constant pitch or an angle A transition lattice board with which two or more light transmission grids of a predetermined configuration were formed at constant pitch or an angle A photo detector which receives a reflected light image which outgoing radiation was carried out from said light source, penetrated said light transmission grid, and was reflected by said reflecting grating It is the optical encoder equipped with the above, and it is the grid of a predetermined configuration in which said light transmission grid board and said photo detector were made by common semiconductor substrate, and said photo detector was formed at constant pitch or an angle, and is characterized by detecting the direction of relative displacement and speed of said transition lattice and said reflecting grating based on a detecting signal obtained from each photo detector.
[Claim 2] An optical encoder characterized by forming said photo detector and said light transmission grid in said semiconductor substrate by turns in claim 1.
[Claim 3] It is the optical encoder characterized by being a slit for optical passage which formed said light transmission grid in said semiconductor substrate in claim 2, or the thin film portion for light transmission formed in the semiconductor substrate concerned.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] This invention relates to the optical encoder which can be small, and can constitute in a compact and can detect the location

of a migration body etc. with a sufficient precision.

[0002]

[Description of the Prior Art] The detection equipment which detects rotation of a migration body or movement magnitude is called a rotary encoder or a linear encoder, and generally, it is constituted so that the movement magnitude of the migration body which moves united with a transition lattice board may be detected based on quantity of light change of the transmitted light to [a transition lattice board and a stationary grid board are arranged between the light source and a photo detector, passes the transition lattice and stationary grid which are formed in these grid boards, and] a photo detector from the light source.

[0003] What is necessary is just to make a grid pitch small, in order to realize the encoder of a high resolution since the resolution of the optical encoder of this configuration is decided by the grid pitch. However, if the crevice between a transition lattice board and a stationary grid board is not made small according to it, either, in order to make a grid pitch small, a S/N ratio will fall by the leakage of light. Moreover, if crevice fluctuation between the grids accompanying migration of a transition lattice is not made small, either, a S/N ratio will fall.

[0004] Since there is a limit in control of making the crevice between grids small, and crevice fluctuation, in order to avoid the fall of the S/N ratio resulting from leakage and crevice fluctuation of light, the method of using a parallel ray is effective. The optical encoder equipped with such lens optical system is also known that what is necessary is just to use lens optical system, such as a collimate lens, for making emission light from the light source into parallel light. However, the light source currently generally used in the optical encoder is LED, and since LED is not the point light source, it is difficult to obtain a high-definition parallel ray. Moreover, in order to add lens optical system, the part and an equipment size will become large.

[0005] On the other hand, the method of realizing the optical encoder of a high resolution using the diffraction phenomena of light is learned. In the encoder by this method, the movement magnitude of a migration body is detected based on change of the light income in the diffraction generated in case the grid of a minute pitch is made to penetrate the light by which outgoing radiation was carried out from the point light sources, such as semiconductor laser, and parallel Guanghua was carried out with the lens and parallel light penetrates a grid, and the photo detector resulting from interference. When this method is adopted, compared with the encoder of the above-mentioned configuration, a grid pitch can be made small, and since distribution of the light by interference is close to a sine wave, accurate electric division can be performed. However, since the grid itself and an equipment device are asked for high degree of accuracy, there is a defect that an equipment price is high and the reliability of the semiconductor laser used as the light source is low.

[0006] Next, as an optical encoder, it lets a lens pass and the spatial filter encoder which carries out image formation to the photo detector which arranged the image of a transition lattice in the shape of a grid is proposed in JP,6-118088,A by this application people. It is possible to be able to acquire the signal near a sine wave, therefore to raise resolution according to the screen effect, by this method, using a divider, since the harmonic content of the signal produced by grid migration can be negated. However, when a grid pitch is made small, it is difficult to raise the contrast of a light-receiving

light figure, and in order to use lens optical system, there is a defect that an equipment size becomes large.

[0007]

[Problem(s) to be Solved by the Invention] Here, it is "application of ITS to the image formation analysis and displacement measurement of a grating" (it SPIE(s)). The 136th volume, the 1st Council of Europe about the application to the measuring study of optics (1977), The 325-332nd page () ["ANALYSIS] OF GRATING IMAGING AND ITS APPLICATIONTO DISPLACEMENT METROLOGY" and SPIE Vol.136 1 st European Congress on OpticsApplied to Metrology (1977), The theory of a three-sheet grid and the application to displacement measurement are reported to pp.325-332. The movement magnitude of a reflecting grating is detectable by an index grid board and a reflecting grating board being confronted, arranging the source of luminescence, and a photo detector behind an index grid board, and outgoing radiation being carried out from the light source, penetrating the index grid of an index grid board, being reflected by the reflecting grating of a reflecting grating board, and detecting the light which penetrated the index grid again by the photo detector as indicated by this report.

[0008] According to this configuration, even if it enlarges the gap of an index grid and a reflecting grating, the effect on the contrast resulting from ****** and crevice fluctuation of these grids does not almost have effect in contrast, either.

[0009] Therefore, if based on the theory of the three-sheet grid using a reflecting grating, the optical encoder of a high resolution which does not receive effect in extensive ** of the gap of a stationary grid and a transition lattice or fluctuation of the gap concerned is realizable.

[0010] However, in applying to an optical encoder, the following technical problems which should be solved occur.

[0011] first, in the encoder of this structure, the source of luminescence and a photo detector are arranged behind an index grid -- required -- by a certain **, structure is complicated and there is a trouble that quantity of light detection efficiency is also low. Moreover, to use as an encoder, in order to detect the migration direction of the migration body for detection, it is required to make the signal with which at least two photo detectors were used, and the phase shifted mutually by 1/4 phase. However, it is difficult to realize the configuration which takes out the signal with which the source of luminescence and at least two photo detectors have been arranged behind an index grid, and the phase shifted from these photo detectors to it by 1/4 phase.

[0012] In view of such a point, based on the theory of the three-sheet grid using a reflecting grating, the technical problem of this invention is small, can be constituted in a compact, and is to realize the optical encoder which can detect passing speed and the migration direction (migration location) moreover.

[0013]

[Means for Solving the Problem] this invention person by making a grid and a photo detector to a common semiconductor substrate under this idea Generation of a signal of a ******** A phase and a B phase is enabled only in about 1/4 phase. [required in order to detect the migration direction of a migration body] With, it came to invent a compact optical encoder by small [for detecting movement magnitude of a migration body], without receiving effect in extensive ** of a gap of a reflecting grating and a transition lattice, and fluctuation of the gap concerned.

[0014] Namely, a reflecting grating board with which, as for this invention, two or more reflecting gratings were formed at the light source, and constant pitch or an angle, A transition lattice board with which two or more light transmission grids were formed at constant pitch or an angle, It is the optical encoder which has a photo detector which receives a reflected light image which outgoing radiation was carried out from said light source, penetrated said light transmission grid, and was reflected by said reflecting grating. It is made by said light transmission grid board and semiconductor substrate with said common photo detector. Said photo detector is a grid formed at constant pitch or an angle, and it is characterized by detecting the direction of relative displacement and speed (migration location) of said transition lattice and said reflecting grating based on a detecting signal obtained from each photo detector.
[0015] Here, said photo detector and said light transmission grid can be formed in said semiconductor substrate by turns. In this case, said light transmission grid can be used as a slit for optical passage formed in said semiconductor substrate, or a thin film portion for light transmission formed in the semiconductor substrate concerned.
[0016]
[Embodiment of the Invention] The example of the optical linear encoder which applied this invention to below with reference to the drawing is explained.
[0017] Drawing 1 (a) - (c) is drawing showing the outline configuration of the optical linear encoder of this example. If it explains with reference to these drawings, the optical linear encoder 1 of this example consists of fundamentally LED2 as the light source, a semiconductor migration board 3 with which a transition lattice and a photo detector are made, a stationary grid board 4 of a reflective mold, and the control circuit section 5. The photo diode 32 (shading portion in drawing 1 (c)) as the pinstriped grid 31 for light transmission and pinstriped photo detector of fixed width of face is formed in the direction of a plane by turns in the fixed pitch so that it may mention later to the semiconductor migration board 3. The pinstriped reflecting grating 41 of fixed width of face is arranged by the stationary grid board 4 in the direction of a plane in the fixed pitch at surface 4a by the side of light-receiving.
[0018] The control circuit section 5 is equipped with the signal-processing section 51 which forms the A phase signal and B phase signal with which the phase shifted by 1/4 phase based on the detecting signal of photo diode 32, the operation part 52 for calculating migration information, such as passing speed of the semiconductor migration board 3, and the migration direction, based on these A phases and a B phase signal, the display 53 which displays the result of an operation, and the lamp mechanical component 54 which carries out feedback control of the drive of LED2.
[0019] In addition, the above-mentioned operation part 52, the display 53, and the lamp mechanical component 54 of your connecting as an external circuit, without building in the control circuit section 5 are natural.
[0020] The cross-section configuration of the slit formation portion for light transmission of the semiconductor migration board 3 and a photo diode formation portion is shown in drawing 2 . The light transmission mold transition lattice 31 of the pinstriped pattern which carried out constant width in the fixed pitch is formed of dirty removal so that this semiconductor migration board 3 may be equipped with the semiconductor substrates 33, such as a silicon substrate, and this semiconductor substrate 33 may understand it from drawing 2 (b).

[0021] The photo diode 32 of the pn junction which consists of semiconductor substrate portion 34 concerned and a boron dope layer 35 formed by doping boron from this surface is made by the portion of the semiconductor substrate which remains between each transition lattice 31 in the semiconductor substrate 33 so that drawing 2 (a) may show. Of course, photo diode 32 may be made to the semiconductor substrate 33 by methods other than this.

[0022] The electrode layer 36 made from aluminum is connected to the boron dope layer 35 of each photo diode 32, and the same common electrode layer 37 made from aluminum is connected to the semiconductor substrate 33 side. Of course as an electrode material, conductive materials other than aluminum can be used.

[0023] It is insulated between the electrode layer 36 and the semiconductor substrate 33 by the insulating layer 38 which consists of silicon oxide. Moreover, the exposure surface of the semiconductor substrate 33 is covered with silicon oxide in order to secure endurance. Similarly, the surface of the boron dope layer 35 is also covered with silicon oxide.

[0024] In thus, the direction which is made to unite the semiconductor migration board 3 with a measuring object object (not shown), and intersects perpendicularly with an optical axis L in the constituted linear encoder 1 of this example And if it is made to move in a slit and the array direction of photo diode, first, the outgoing radiation light from LED irradiates the back of the semiconductor migration board 3, will pass the grid 31 for light transmission currently formed in the semiconductor migration board 3 concerned, and will irradiate the reflective mold stationary grid board 4 in the shape of plaid.

[0025] Since the reflecting grating 41 of the same width of face of a fixed pitch is formed also in the stationary grid board 4, as for the light which irradiated the stationary grid board 4 concerned, only an exposure portion is reflected in each reflecting grating 41. A reflecting grating image irradiates the semiconductor migration board 3 again, and is received by the pinstripes-like photo diode 32 currently formed with the constant width of a fixed pitch. Thus, in this example, the pinstriped grid 31 for light transmission and the photo diode 32 which were formed in the semiconductor migration board 3 function as two grid boards. Therefore, based on the theory of the three-sheet grid using a reflecting grating, light income changes in the shape of a sine wave in photo diode 32 corresponding to the relative displacement of a reflecting grating 41 and a transition lattice (31 32). Therefore, based on the photocurrent of photo diode 32, the pulse signal corresponding to relative-displacement speed can be obtained, and relative-displacement speed can be calculated based on the pulse rate of the pulse signal concerned.

[0026] Moreover, as shown in drawing 1 (a), it is also possible to generate an A phase signal and only for 1/4 phase to generate the B phase signal with which the phase shifted based on total of the output of the even-numbered photo diode based on total of the output of the odd-numbered photo diode. The migration direction of a transition lattice can be distinguished based on the signal of these two phases.

[0027] Thus, in the optical linear encoder 1 of this example, since the transition lattice and the photo detector are made by the semiconductor manufacturing technology and the grid of a minute pitch can be manufactured, the encoder of a high resolution is realizable.

[0028] Moreover, since the photo detector formed in the shape of pinstripes at constant pitch functions as a grid and the grid concerned itself moreover has the lens effect, there is no necessity of using lens optical system, and the miniaturization of equipment can be attained.
[0029] Furthermore, by the theory of a three-sheet grid, since extensive ** of the crevice between a reflecting grating and a transition lattice and fluctuation of the crevice concerned do not have a bad influence on resolution, the tuning for securing the installation precision of the member in which these are formed can be simplified, and constraint of an installation location decreases.
[0030] In addition, since the gap of a reflecting grating and a transition lattice can be made large, there is an advantage, like it also becomes possible to contain a reflecting grating side to a protective case etc., for example, and to raise a resistance to environment.
[0031] (Array of a photo detector) The pinstriped grid 31 for light transmission formed in the semiconductor migration board 3 and the example of an array of photo diode 32 are shown in drawing 4 .
[0032] The example shown in drawing 4 (a) is the so-called example of character arrangement of a rice field, and the fields 301-304 where the pinstriped grid for light transmission and pinstriped photo diode were formed in four places by turns so that it might become the shape of a character of a rice field are formed in semiconductor substrate 3A. Here, an A phase signal is acquired from the photo diode group of a field 301, and a B phase signal is acquired from the photo diode group of the field 302 which has shifted to 1 / 8 pitch longitudinal direction to this field 301.
[0033] In the location of the field 301 bottom, the reversal signal of an A phase is acquired from the photo diode group of 1 / 16 pitch gap ****** field 303 in a longitudinal direction to the field concerned, and similarly, it is constituted so that the reversal signal of a B phase may be acquired from the photo diode group of 1 / 8 pitch gap ****** field 304 in a longitudinal direction to the field 303 concerned.
[0034] The example shown in drawing 4 (b) is an example of train arrangement, and the fields 401-404 of four trains are formed in the direction which intersects perpendicularly in the migration direction of the substrate concerned at semiconductor substrate 3B. The pinstriped grid for light transmission and pinstriped photo diode are formed in the top field 401 by turns in the fixed pitch towards the substrate migration direction. As for the field 402, 1 / 8 pitch gap ******, the grid for light transmission, and photo diode are formed in the longitudinal direction by turns to the field 401. As for the field 403 of this field 402 bottom, 1 / 16 pitch gap ******, the grid for light transmission, and photo diode are formed in the longitudinal direction by turns to the top field 401.
[0035] Furthermore, as for the field 404, 1 / 16 pitch gap ******, the grid for light transmission, and photo diode are formed in the longitudinal direction by turns to the field 402. An A phase signal is acquired from the photo diode group of a field 401, a B phase signal is acquired from the photo diode group of a field 402, the reversal signal of an A phase is acquired from the photo diode group of a field 403, and the reversal signal of a B phase can be acquired from the photo diode group of a field 404.
[0036] Drawing 4 (c) is the example of grid arrangement, and three fields 501-503 are formed in the migration direction (longitudinal direction) of semiconductor substrate

3C in two or more fields at a fixed gap, and drawing. Pinstriped light transmission partial 31C (portion shown with a slash) and pinstriped photo diode 32C formed among these are formed in each field in the pitch fixed by turns.

[0037] Between the adjoining fields 501 and 502, if between fields 502 and 503 is made into one pitch, as each field has the width of face of 1/2 pitch and shows it there at drawing 4 (d), four photo diode 32C is formed. The width of face of each photo diode 32C is 1/16 pitch, and the gap of photo diode is 1/8 pitch. Although the crevice between 1/32 pitches is open between the photo diode of right-and-left both sides, and a field boundary, this crevice is not limited to 1/32 pitch.

[0038] In addition, the ratio of the grid for light transmission or a light transmission portion, and each width of face of photo diode is not limited to 1:1, either.

[0039] (The improvement method of a S/N ratio) Next, since light is irradiated from the rear-face side, the dark current increases and the photo diode 32 formed in the semiconductor migration board 3 of the above-mentioned configuration has a possibility that a S/N ratio may fall. What is necessary is just to perform it as follows, in order to avoid this evil.

[0040] What is necessary is just to carry out the laminating of the reflective film (protection-from-light film) which is from materials, such as aluminum and gold, on the rear-face, i.e., the light source, side in the semiconductor migration board 3 by methods, such as vacuum evaporationo, as shown in drawing 5 . In this case, if a reflective film is formed also in the side portion of photo diode 32, an effect will become good more. In drawing, the dotted line has shown the field which can form a reflective film.

[0041] (The formation method of a light transmission portion) He etches a semiconductor migration board in the direction which intersects perpendicularly to the surface, and is trying to form a slit by dry etching in the above-mentioned example. Instead, the wet etching which is the cheap manufacture method is also employable. In this case, it becomes the anisotropic etching resulting from crystal orientation, and the slit of the side which inclined to the semiconductor substrate surface as shown in drawing 6 is formed.

[0042] Also in this case, if a reflective film is formed in the portion shown by the dotted line by methods, such as vacuum evaporationo, the dark current of photo diode can be reduced at the rear face (light source side) of the portion which remains as photo diode, and a S/N ratio can be improved into it to it.

[0043] (Gestalt of other operations) In addition in this example, it is also possible it to instead form the thin film which can penetrate sufficient quantity of light by etching to a semiconductor substrate at a semiconductor substrate, although the light transmission mold transition lattice 31 of the semiconductor migration board 3 is a slit for open beam light passage, and it to use each thin film portion as a transition lattice.

[0044] Moreover, as shown in drawing 3 , it is also possible to form the thin film portion which can penetrate sufficient light, and to use the thin film portion concerned as transition lattice 31A by etching the portion by the side of the rear face of semiconductor substrate 33A in which photo diode 32A is formed. Such a transparent semiconductor photo detector is proposed in the specification of Japanese Patent Application No. No. 120848 [ten to] of April 30, Heisei 10 presentation at this invention person of one person, and the drawing.

[0045] On the other hand, although the side in which the reflecting grating 41 is formed

is used as the fixed side in the above-mentioned example, it is also possible to turn on a reflecting grating 41 side concerned migration-side, and to use the semiconductor migration board 3 side as a fixed side.

[0046] Moreover, although LED is used as the light source in the above-mentioned example, it is also possible to use the light source of others, such as the laser light source.

[0047] Furthermore, although the above-mentioned example is related with a linear encoder, this invention is applicable similarly to a rotary encoder. In this case, what is necessary is to turn a light transmission portion and the portion of photo diode to a circumferencial direction, and just to form them at a fixed angle.

[0048]

[Effect of the Invention] As explained above, while forming in a photo detector the reflecting grating image which can detect the information about such relative displacement using a reflecting grating and a transition lattice based on three-sheet grid theory in the optical encoder of this invention, the configuration which made the transition lattice and the photo detector on the common semiconductor substrate is adopted.

[0049] Therefore, what is necessary is just according to the encoder of this invention, not to arrange the photo detector as another components to the backside of a transition lattice, and to only arrange the light source to it. Moreover, since the photo detector of the shape of a grid formed in the semiconductor substrate itself has the lens effect, a spatial filter encoder can be realized, without using lens optical system. Therefore, it is small and equipment can be used as a compact.

[0050] Moreover, since the transition lattice is formed in a semiconductor substrate, there is an advantage that the grid of a minute pitch can be formed with a sufficient precision by the semiconductor manufacturing technology.

[0051] Furthermore, there is also an advantage that installation of the components with which these reflecting gratings and a transition lattice are formed becomes easy, and constraint of the installation location of these components also becomes loose by the theory of a three-sheet grid since the contrast of a detecting signal does not fall by extensive ** of the gap of a reflecting grating and a transition lattice and fluctuation of the gap concerned.

[Translation done.]

PATENT ABSTRACTS OF JAPAN

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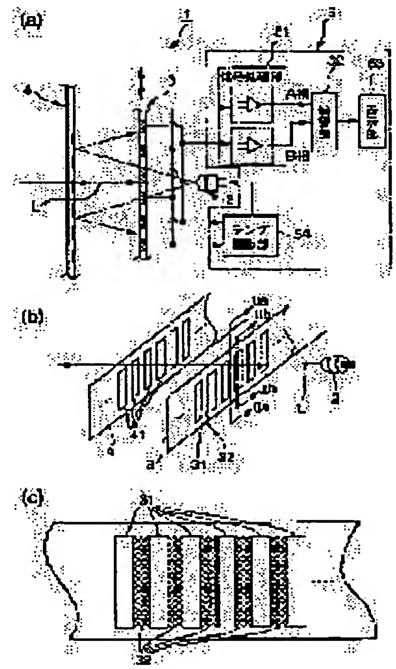
(54) OPTICAL ENCODER

(57)Abstract:
PROBLEM TO BE SOLVED: To provide an optical encoder which uses a reflecting lattice and a light transmission-type lattice, which is based on the theory of three lattices, which is small and compact and whose resolution is high.
SOLUTION: In this optical linear encoder 1, light from an LED 2 passes a light transmission moving lattice 31 formed on a semiconductor moving plate 3 so as to be then reflected by a reflecting grating 41 on a reflecting grating plate 4. A reflected grating image is detected by a lattice-shaped photodiode 32 formed on the semiconductor moving plate 3. The moving lattice 31 and the photodiode 32 are formed on a common semiconductor substrate, and lens effect is obtained by the lattice-shaped photodiode 32. As a result, a lens optical system is not required, and the encoder which is small and compact can be realized. In addition, on the basis of the theory of three lattices, whether the interval between the reflecting grating and the moving grating is wide or narrow and a change in the interval do not have a bad influence on the detecting accuracy of the encoder. As a result, the components can be attached simply, and the restriction on the mounting position of the components is relaxed.



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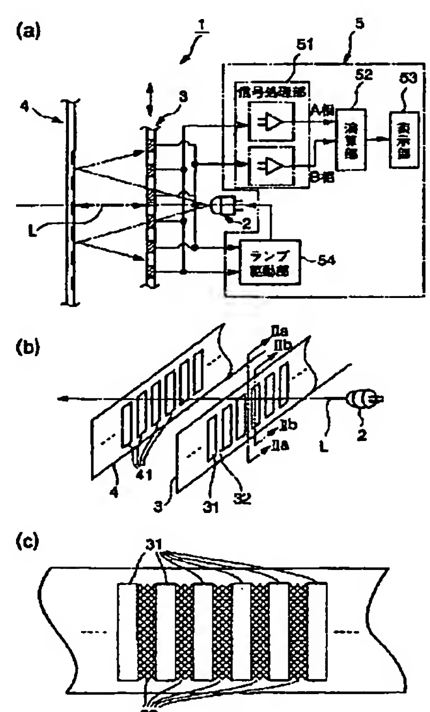
最終頁に続く

(54)【発明の名称】　光学式エンコーダ

(57)【要約】

【課題】　反射格子および光透過型の格子を用いて、３枚格子の理論に基づき、小型コンパクトで分解能の高い光学式エンコーダを実現すること。

【解決手段】　光学式リニアエンコーダ１では、ＬＥＤ２からの光は、半導体移動板３に形成した光透過型の移動格子３１を通過した後に反射格子板４の反射格子４１で反射される。反射格子像は、半導体移動板３に形成されている格子状のホトダイオード３２によって検出される。移動格子３１およびホトダイオード３２が共通の半導体基板に作り込まれており、しかも、格子状のホトダイオード３２によってレンズ効果が得られるのでレンズ光学系が不要となるので、小型でコンパクトなエンコーダを実現できる。また、３枚格子の理論に基づき反射格子と移動格子の間隔の広狭、当該間隔の変動が検出精度に悪影響を及ぼすことがないので、これらの部品の取り付けが簡単になり、また取り付け位置の制約も緩和される。



ストへの影響も殆どない。

【０００９】したがって、反射格子を用いた３枚格子の理論に基づけば、固定格子および移動格子の間隔の広狭あるいは当該間隔の変動に影響を受けることのない高分解能の光学式エンコーダを実現可能である。

【００１０】しかしながら、光学式エンコーダに適用するに当たっては次のような解決すべき課題がある。

【００１１】まず、この構造のエンコーダでは、インデックス格子の後ろに、発光源と受光素子を配置する必要あるので、構造が複雑化し、光量検出効率も低いという問題点がある。また、エンコーダとして用いる場合には、検出対象の移動物体の移動方向を検出するために少なくとも２つの受光素子を用いて相互に位相が１／４位相分だけずれた信号を作り出すことが必要である。しかし、インデックス格子の後ろに、発光源および少なくとも２個の受光素子を配置し、これらの受光素子から１／４位相分だけ位相がずれた信号を取り出す構成を実現することは困難である。

【００１２】本発明の課題は、このような点に鑑みて、反射格子を用いた３枚格子の理論に基づき、小型でコンパクトに構成でき、しかも、移動速度および移動方向（移動位置）を検出することのできる光学式エンコーダを実現することにある。

【００１３】

【課題を解決するための手段】本発明者は、かかる着想の下に、共通の半導体基板に格子と受光素子を作り込むことにより、移動物体の移動方向を検出するために必要な１／４位相だけ位相ずれたＡ相およびＢ相の信号を生成可能とし、以て、反射格子および移動格子の間隔の広狭および当該間隔の変動に影響を受けることなく移動物体の移動量を検出するための小型でコンパクトな光学式エンコーダを案出するに到ったのである。

【００１４】すなわち、本発明は、光源と、一定ピッチあるいは角度で反射格子が複数本形成された反射格子板と、一定ピッチあるいは角度で光透過格子が複数本形成された移動格子板と、前記光源から出射され前記光透過格子を透過して前記反射格子で反射された反射光像を受光する受光素子とを有する光学式エンコーダであって、前記光透過格子板および前記受光素子が共通の半導体基板に作り込まれており、前記受光素子は一定ピッチあるいは角度で形成された格子であり、各受光素子から得られる検出信号に基づき、前記移動格子および前記反射格子の相対移動方向および速度（移動位置）を検出することを特徴としている。

【００１５】ここで、前記半導体基板には、前記受光素子と前記光透過格子を交互に形成することができる。この場合、前記光透過格子は、前記半導体基板に形成した光通過用スリット、あるいは、当該半導体基板に形成した光透過用の薄膜部分とすることができる。

【００１６】

【発明の実施の形態】以下に、図面を参照して本発明を適用した光学式リニアエンコーダの例を説明する。

【００１７】図１（ａ）～（ｃ）は本例の光学式リニアエンコーダの概略構成を示す図である。これらの図を参照して説明すると、本例の光学式リニアエンコーダ１は、光源としてのＬＥＤ２と、移動格子および受光素子が作り込まれている半導体移動板３と、反射型の固定格子板４と、制御回路部５から基本的に構成されている。半導体移動板３には、後述するように、一定のピッチで一定の幅の縦縞状の光透過用格子３１と受光素子としてのホトダイオード３２（図１（ｃ）における網かけ部分）とが平面方向に交互に形成されている。固定格子板４には受光側の表面４ａに、一定のピッチで一定の幅の縦縞状の反射格子４１が平面方向に配列されている。

【００１８】制御回路部５は、ホトダイオード３２の検出信号に基づき１／４位相分だけ位相のずれたＡ相信号およびＢ相信号を形成する信号処理部５１と、これらＡ相およびＢ相信号に基づき半導体移動板３の移動速度、移動方向等の移動情報を演算するための演算部５２と、演算結果を表示する表示部５３と、ＬＥＤ２の駆動をフィードバック制御するランプ駆動部５４とを備えている。

【００１９】なお、上記の演算部５２、表示部５３、ランプ駆動部５４は制御回路部５に内蔵せずに、外部回路として接続してもよいことは勿論である。

【００２０】図２には半導体移動板３の光透過用スリット形成部分およびホトダイオード形成部分の断面構成を示してある。この半導体移動板３はシリコン基板等の半導体基板３３を備え、この半導体基板３３には、図２（ｂ）から分かるように、一定のピッチで一定幅をした縦縞模様の光透過型移動格子３１がエッチ除去により形成されている。

【００２１】図２（ａ）から分かるように、半導体基板３３における各移動格子３１の間に残っている半導体基板の部分には、当該半導体基板部分３４と、この表面からボロンをドープすることにより形成したボロンドープ層３５から構成されるｐｎ接合のホトダイオード３２が作り込まれている。勿論、これ以外の方法によりホトダイオード３２を半導体基板３３に作り込んでもよいことは勿論である。

【００２２】各ホトダイオード３２のボロンドープ層３５にはアルミニウム製の電極層３６が接続されており、半導体基板３３の側には同じくアルミニウム製の共通電極層３７が接続されている。電極素材としてはアルミニウム以外の導電性素材を用いることができることは勿論である。

【００２３】電極層３６と半導体基板３３の間はシリコン酸化膜からなる絶縁層３８により絶縁されている。また、半導体基板３３の露出表面は耐久性を確保するためにシリコン酸化膜によって覆われている。同様に、ボロ

開いているが、この隙間は１／３２ピッチに限定されるものではない。

【００３８】なお、光透過用格子あるいは光透過部分と、ホトダイオードのそれぞれの幅の比も１：１に限定されるものではない。

【００３９】（S／N比の改善方法）次に、上記構成の半導体移動板３に形成されたホトダイオード３２は、その裏面側から光が照射されるので、その暗電流が増加し、S／N比が低下するおそれがある。この弊害を回避するためには次のようにすればよい。

【００４０】図５に示すように、半導体移動板３における裏面側、すなわち、光源側に、アルミニウム、金等の素材からなる反射膜（遮光膜）を蒸着等の方法により、積層すればよい。この場合、ホトダイオード３２の側面部分にも反射膜を形成すればより効果が良くなる。図においては、反射膜の形成可能な領域を点線で示してある。

【００４１】（光透過部分の形成方法）上記の例ではドライエッチングにより半導体移動板を、その表面に対して直交する方向にエッチングしてスリットを形成するようにしている。この代わりに、安価な製造方法であるウエットエッチングを採用することもできる。この場合には、結晶方位に起因した異方性エッチングとなり、図６に示すように半導体基板表面に対して傾斜した側面のスリットが形成される。

【００４２】この場合においても、ホトダイオードとして残っている部分の裏面（光源側）に、点線で示す部分に、反射膜を蒸着等の方法により形成すれば、ホトダイオードの暗電流を低減でき、S／N比を改善できる。

【００４３】（その他の実施の形態）なお、本例においては、半導体移動板３の光透過型移動格子３１は、半導体基板に開けた光通過用のスリットであるが、この代わりに、充分な量の光が透過できる薄膜を半導体基板に対してエッチングにより形成し、各薄膜部分を移動格子とすることも可能である。

【００４４】また、図３に示すように、ホトダイオード３２Aが形成されている半導体基板３３Aの裏面側の部分をエッチングすることにより、充分な光が透過可能な薄膜部分を形成し、当該薄膜部分を移動格子３１Aとして利用することも可能である。このような透明な半導体受光素子は、本発明者の一人によって、平成１０年４月３０日提出の特願平１０－１２０８４８号の明細書、図面において提案されている。

【００４５】一方、上記の例では、反射格子４１が形成されている側を固定側としてあるが、当該反射格子４１の側を移動側とし、半導体移動板３の側を固定側とすることも可能である。

【００４６】また、上記の例では光源としてLEDを用いてるが、レーザー光源等のその他の光源を利用することも可能である。

【００４７】さらに、上記の例はリニアエンコーダに関するものであるが、ロータリーエンコーダに対しても本発明を同様に適用可能である。この場合には、光透過部分とホトダイオードの部分とを、円周方向に向けて一定の角度で形成すればよい。

【００４８】

【発明の効果】以上説明したように、本発明の光学式エンコーダにおいては、３枚格子理論に基づき反射格子と移動格子を用いてこれらの相対移動に関する情報を検出可能な反射格子像を受光素子に形成すると共に、移動格子と受光素子を共通の半導体基板上に作り込んだ構成を採用している。

【００４９】従って、本発明のエンコーダによれば、移動格子の後ろ側に、別部品としての受光素子を配置する必要がなく単に光源を配置するだけでよい。また、半導体基板に形成された格子状の受光素子そのものがレンズ効果を持つので、レンズ光学系を用いることなく空間フィルタエンコーダを実現できる。よって、装置を小型でコンパクトにすることができる。

【００５０】また、半導体基板に移動格子を形成しているので、微小ピッチの格子を半導体製造技術により精度良く形成できるという利点がある。

【００５１】さらには、３枚格子の理論により、反射格子と移動格子の間隔の広狭、および当該間隔の変動により検出信号のコントラストが低下してしまうこともないので、これら反射格子および移動格子が形成されている部品の取り付け作業が簡単になり、また、これらの部品の取り付け位置の制約も緩やかになるという利点もある。

【図面の簡単な説明】

【図１】（a）～（c）は、本発明を適用した光学式リニアエンコーダの構成を示す説明図である。

【図２】（a）および（b）は、図１の半導体移動板に形成されたホトダイオードおよび光透過型移動格子の部分の概略断面構成図である。

【図３】半導体移動板の別の例を示す断面構成図である。

【図４】（a）～（d）は、受光素子における光透過部分およびホトダイオードからなる領域の配置形態の３例を示す説明図である。

【図５】受光素子のS／N比を改善するための方法を示す説明図である。

【図６】受光素子の光透過部分をウエットエッチングにより形成する場合を示す説明図である。

【符号の説明】

１　光学式リニアエンコーダ

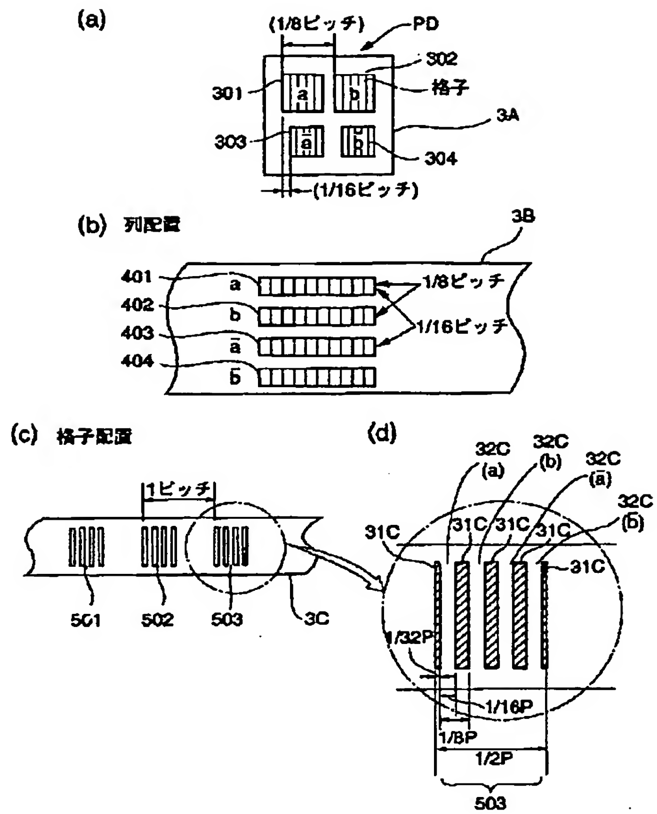
２　LED

３　半導体移動板

３１　光透過型の移動格子

３２　ホトダイオード

【図４】



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